HOW TO WIND HIGH FREQUENCY COILS WITHOUT A LATHE

By the Laboratory Staff

THE editorial correspondence of the past few months has disclosed a surprising dearth of knowledge among the readers on what we had assumed to be "old stuff." We have found that many readers, for instance, have refrained from attempting to build large high frequency coils merely because they had no lathe in which to do the winding.

In many of our articles and books we have specified a simple winding rig which, to us, seemed so simple that no lengthy explanation was necessary. Such is apparently not the case, however, for the questions continue to come in. Instead of attempting to answer all of the many queries through *The Technical Adviser* we have made a short article of the subject and have incorporated illustrations made from our own apparatus in the Experiment Station.

Fig. 1 is a photograph of a finished coil wound upon a cardboard cylinder, 7 in. diameter (outside) and 18 in. long. The photograph shows all there is to the winding rig. Fig. 2 shows the parts dissected, and the reader will observe that the winder embodies two upright pieces of wood mounted upon a base; two discs cut out on a scroll saw to fit tightly into the cardboard cylinder, one at either end; and two stove bolts, ¼-20 in size, one of which is fitted with a crude crank and handle to facilitate turning the cylinder.

Below the winder and attached to the face of the bench with wood screws is a rig for holding the magnet wire. This consists of two supports through which a length of wooden dowel is passed. This rod will hold two large spools of wire at one time to take care of the double winding to be described. No tension is used on the wire, as the spools unwind slowly as the cylinder is turned by hand. And right here let us say that the hand winding is not at all slow; if a lathe were used, it would have to be run at the lowest speed and *backward*.

In Fig. 3 the boys are doing the trick. This photograph shows a double winding being placed. On this cylinder the effective winding is to be a single layer of No. 24 D. S. C. magnet wire, and each turn is to be spaced from its neighbor by the thickness of a piece of No. 30 D. C. C. wire. Obviously, the simplest way to accomplish this is to wind both the silk and the cotton covered wires

on in parallel and afterward to remove the cotton, leaving the silk wire in position with turns evenly spaced throughout the length of the cylinder.

one of these brads (see starting of winding in Fig. 3). This permits of removal without disturbing the silk covered wire at the starting point.

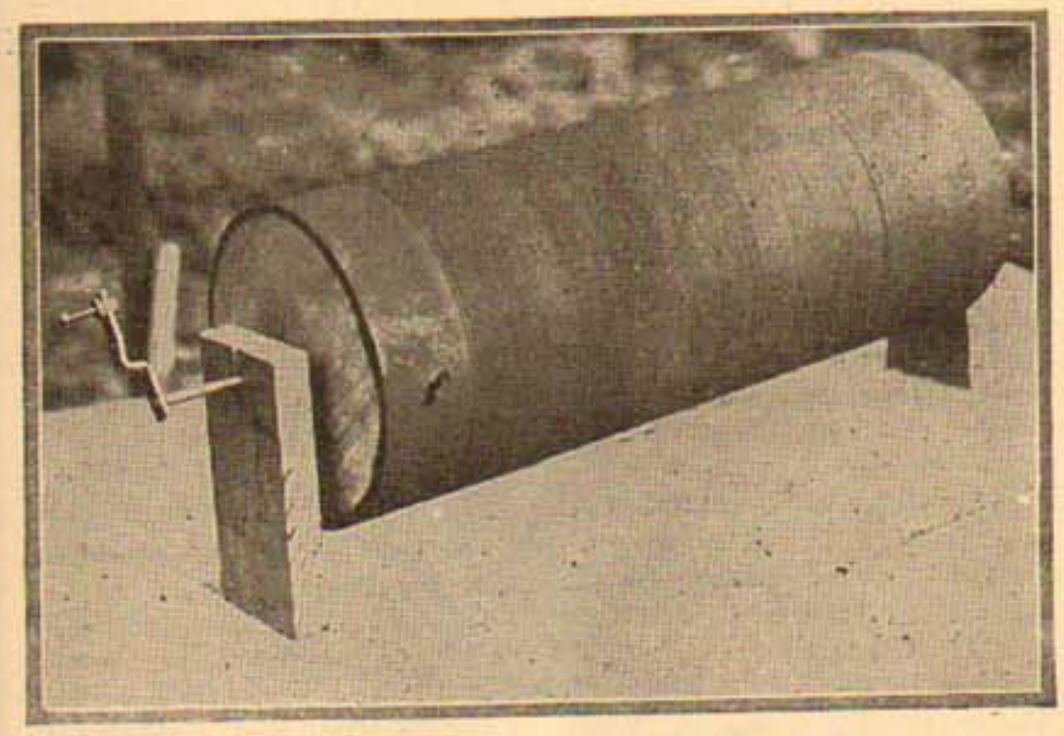


Fig. 1. A coil already wound in the winding rig

To perform the double winding, the permanent wire, *i. e.*, the No. 24 silk covered, is passed through a small hole punched in the cylinder at a distance of an inch from the left-hand end. This hole is then plugged with a piece of match stick dipped in thick shellac. The wooden discs should have been secured in the cylinder by means of small brads with heads left projecting for easy removal. The cotton covered wire may then be wrapped around

Both spools of wire are placed on the dowel of the wire holder and the base of the winder screwed or clamped to the bench before starting the work. When the end of each wire has been secured, one operator grasps the crank handle and commands the double wire. The two wires are held between thumb and forefinger and *close together*. The middle and third fingers then separate the wire as it comes from the spools. The assistant

stands ready to exert pressure on the cylinder when necessary, for this double winding is essentially a two-man job.

Starting a turn or two and making sure the wires are parallel and *not crossed*, the operator may proceed to wind until a "true turn" is taken. By true turn we mean a turn that goes on accurately and is concentric with the edge of the cylinder; the first few turns will not be true—they will vary as the hand wavers in guiding the wire. After the first true turn is placed, the starting turns may be gently shoved up to it in order to start a true winding.

From this point on, the work is plain sailing. The operator winds slowly at first, while the assistant maintains pressure with his finger tips, as shown in Fig 3. The one disagreeable feature is the irritation to the eyes. When winding the green silk and white cotton covered wires in parallel, the vision is so confused that everything is a blur after a few minutes. The imperative move right here is to rest the eyes by looking off at a distance and preferably out of the window if there are green fields and trees in the distance. A few moments will do wonders, when the winding may proceed.

After some little practice, the operators will be able to literally spin the cylinder, and the time consumed in winding the coil is really but fifteen or twenty minutes. This proficiency is attained, however, only after practice.

In Fig. 4 we see the duplicate wire being unwound. This operation is performed only after the end of the silk covered wire has been secured in precisely the same manner as the starting end—with the wooden plug through the wall of the cylinder. In removing the wire from the cylinder, we of course use the lathe to spin the wire spool. The worker who has no lathe may turn the spool by hand or else mount it on the end of a hand drill, winding the wire by turning the drill crank.

Choice of Windings

The number of turns placed on the cylinder determines the length, quality and characteristics of the spark delivered by the coil. The cylinder just described requires about six turns of primary of any convenient form, a condenser of between .01 and .02 mfd. (see condenser article in this issue), and a transformer of the standard wireless type of from ½ to 1 kilowatt capacity. With a ½-kilowatt magnetic leakage transformer, the cylinder gives a beautiful spark, thick and white, and of a frequency so high that no perceptible shock can be felt. The length of the spark varies with different points of tuning from 6 in. to 18 in.

Now for comparison, the same size of cylinder wound with No.

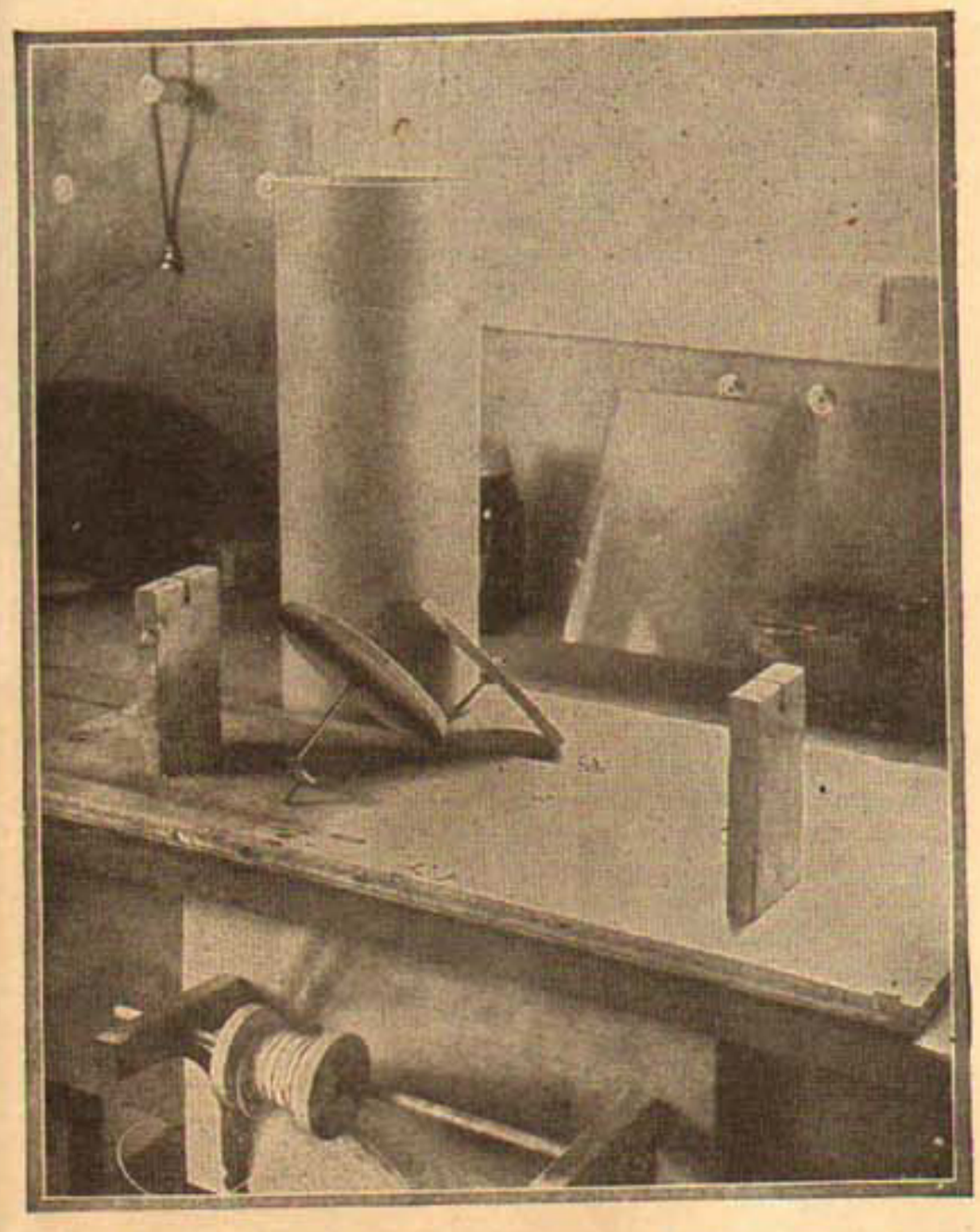


Fig. 2. The various parts of the winder and the cardboard cylinder

30 double cotton covered wire wound close or without any separation whatever, gives a spark quite distinctively different. The streamers are thin and blue and of a hairlike texture. They

do not appear nearly so angry as those from the other winding, but on taking the discharge through the body, we find the frequency has been lowered so that we get an appreciable shock—not a bad one, but we can feel it. The length of the spark is rather greater, but the spark is thin. The condenser is larger—about .02 to .03 mfd., and the primary has sixteen turns.

If we insert a variable resistance or a choke coil in series with the primary of the transformer, and open out the spark gap, we get a periodic discharge that almost exactly simulates the discharge of an induction coil with a slow vibrating interrupter. Carrying the resistance higher, we get a very slow, crackling spark of the true static type This spark is cold to the touch, but it causes much greater muscular contraction than before One can feel the impulses of the current and see the muscles respond in the bare arm

The choice of winding will rest with the individual For us—we can never make enough of them. Every time we try something new we learn more and disprove our former theories The cost is so low that the true high frequency fan will go after all of the variations he can think of. We have given the results of our experiments in a very brief way in this article just for the sake of completeness.

Insulation of the Windings

We use shellac and also a queer compound that we have hit upon by accident The formula will not be published just yet for the simple reason that we are not sure just yet what we have in the mixture. Suffice it to say that our best coils and the most durable ones have been those coated very liberally with shellac and most thoroughly dried. Then after three or four coats of shellac have dried in, we give them a final coat of armalac or this new mixture of ours. The secret of success is to have patience to *thoroughly* dry out the shellac after every coat We allow it to dry for days before putting current through the winder.

Wax can be used and, in this connection, beeswax is the only thing It is costly but worth its price For a cheaper compound and one mechanically much harder beeswax and rosin may be used in equal parts The wax insulation should be put on by melting the compound in a shallow pan and slowly revolving the coil (on its winding supports) through the molten mixture. The revolutions should continue after the wax has been taken away, to insure an even coating as the mixture dries and hardens on the surface of the cylinder

We do not favor this wax insulation particularly, as we have had such good success with the other compounds. However, in

Fig. 3. Starting the winding. Note how the wire is guided

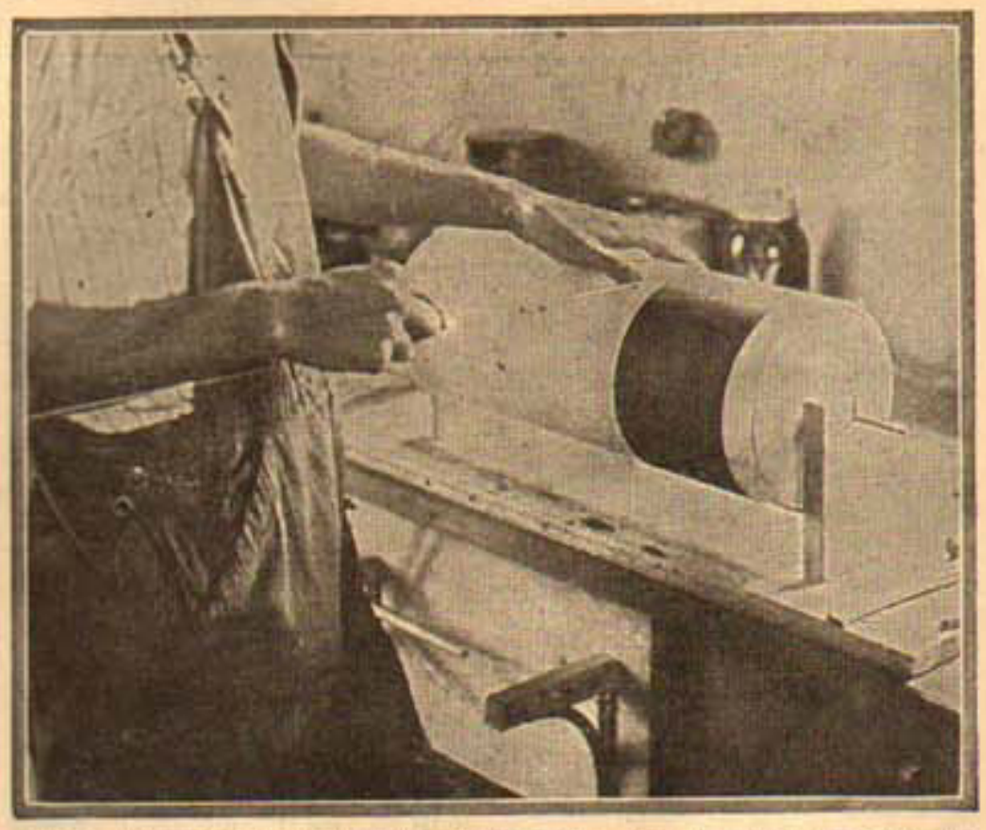


Fig. 4. Removing the extra wire used for spacing. This is done by winding the coil backward and starting where the winding was finished

quiries constantly come in regarding it, and we have suggested the one method we have found practicable for the case in hand. Of course, in the case of a very closely coupled coil such as one of the pancake type described in the March issue, wax is the only thing to use unless oil can be tolerated.

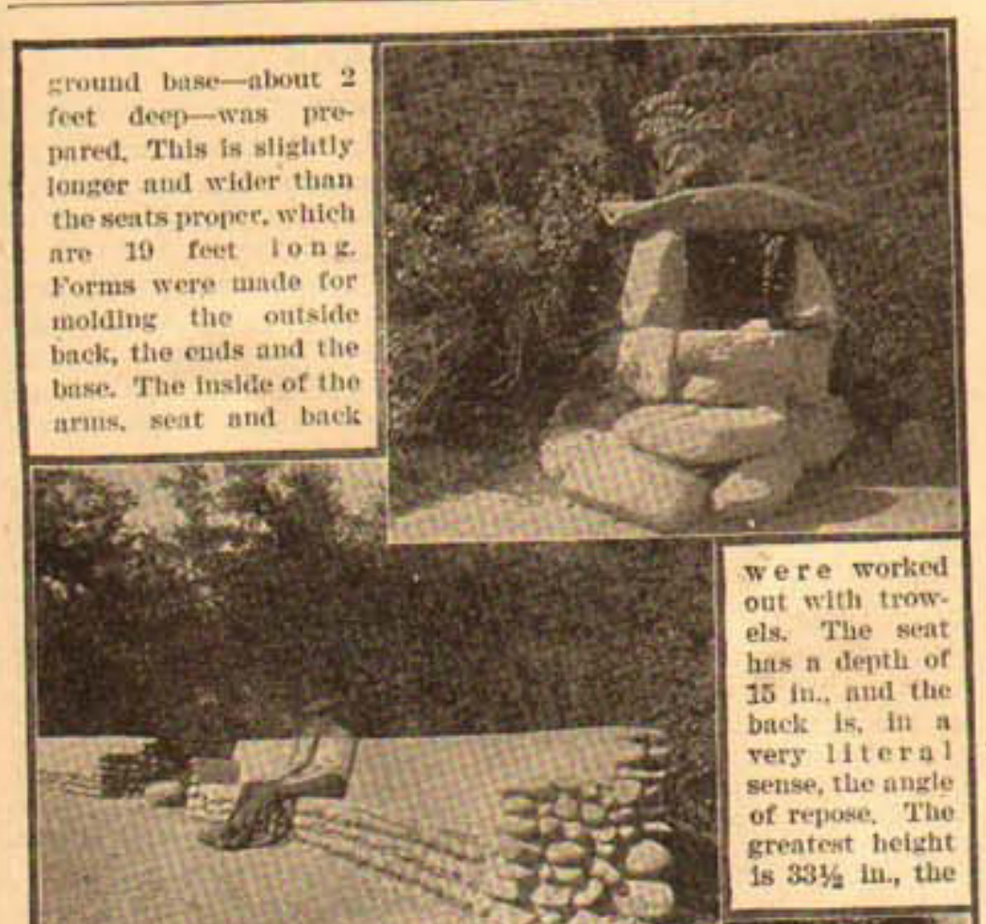
AMATEUR LANDSCAPE GARDENING

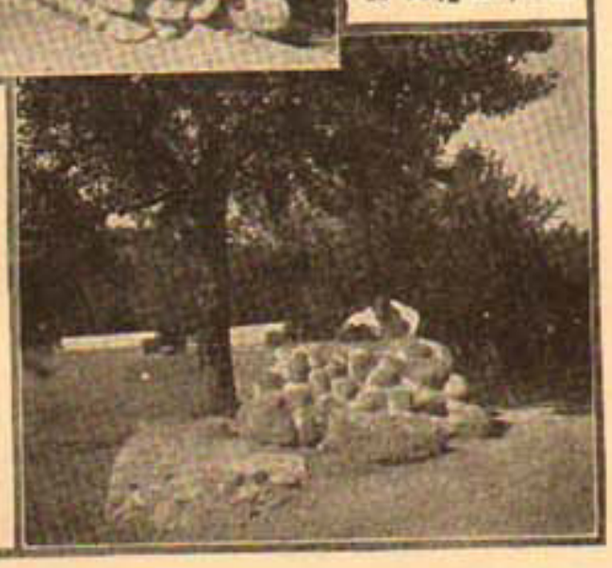
By E. Blair Wall

THE principal of one California school has obtained some very unusual results from her manual training class. Among other things covered is landscape gardening. The two cement and boulder seats shown in the photograph border a cinder track and are a segment of its curve.

Each student brought a supply of the boulders, and the under-

ground base—about 2 feet deep—was prepared. This is slightly longer and wider than the seats proper, which are 19 feet long. Forms were made for molding the outside back, the ends and the base. The inside of the arms, seat and back were worked out with trowels. The seat has a depth of 15 in., and the back is, in a very literal sense, the angle of repose. The greatest height is 33½ in., the thickness at the top about 10 in.





The lower picture is of a drinking fountain built by the same class. The plumbing, of course, was in place before the work was begun. The upper picture, the "Lantern Fountain," was cemented only where security for the stones was needed.

HOW TO BUILD HIGH TENSION CONDENSERS OF ANY SPECIFIED CAPACITY

By the Laboratory Staff

HOW many of our readers know that by means of an astonishingly simple "rule of thumb" method they can build up high tension condensers of any desired or specified capacity with a certainty of results that defies the best efforts of the mathematical designer? True it is, and in this article we propose to tell our readers how we make experimental and standard high tension condensers in the Experiment Station and how we group them so that we know before testing that they are right for the transformer we are to use them with.

Our method is based upon the fact that photographic negatives of the 8 x 10 size are all of about the same thickness and quality; they are, furthermore, quite free from air bubbles and other imperfections. We know that one of these plates coated on both sides with tinfoil, the foil being cut 6 x 8 in. to leave a margin of an inch, has a capacity of approximately .0001 mfd. This is not exact, to be sure, but it is so near that it will answer for all practical purposes. Now, given this basis upon which to work, we may group these single plates into units of five or ten plates each and we have condensers of .005 or .01 mfd. capacity, respectively. By grouping these units into combinations of series or parallel, or both, we can obtain any capacity we require and can also provide the necessary current or "watts" capacity to take care of either large or small transformers.

While various authorities differ on the relative merits of condensers of one type and another, we have found the glass plate type, when built according to the specifications given herein, to be efficient, inexpensive, and durable. It is light in weight compared with the oil-immersed types and is easily constructed.

The first requisite is the photographic negative glass. This can usually be obtained from the local portrait photographer for from five to ten cents a plate. A year ago it could be purchased for half the lower figure, but glass, like everything else, has "gone up." The next will be the tinfoil, which comes in packages of a pound, which contains sufficient foil to cut twenty 6 x 8 in. sheets and sufficient 1 x 6 in. lugs to make up a section of ten plates. The third material entering the construction at present is shellac. The fluid should be thin rather than thick in order that it may spread in an

Fig. 1. Rolling out the wrinkles and creases in the tinfoil. If no photographer's roller is available, a bottle will do

even coating over the glass. For tools, a good brush set in rubber, a sharp knife, a photographic print roller, and some scrap paper will suffice.

The worker begins his operations by spreading out the tinfoil into long strips, rolling out the creases and wrinkles as shown in the illustration, Fig. 1. The rolling should be done on one of the glass plates in order to afford a smooth

surface. When the strips are smooth they may be cut up into sheets 6 x 8 in. by laying the foil on one of the glass plates and using another plate as a straightedge, running the point of the knife along the glass. This cuts and measures at the same time. For an aid to accuracy, measure off a sheet of the correct size and lay it beneath the glass upon which you do the cutting. This sheet showing up from below will provide the necessary guide. When twenty sheets and eleven lugs have been cut, the worker may turn his attention to the pasting.

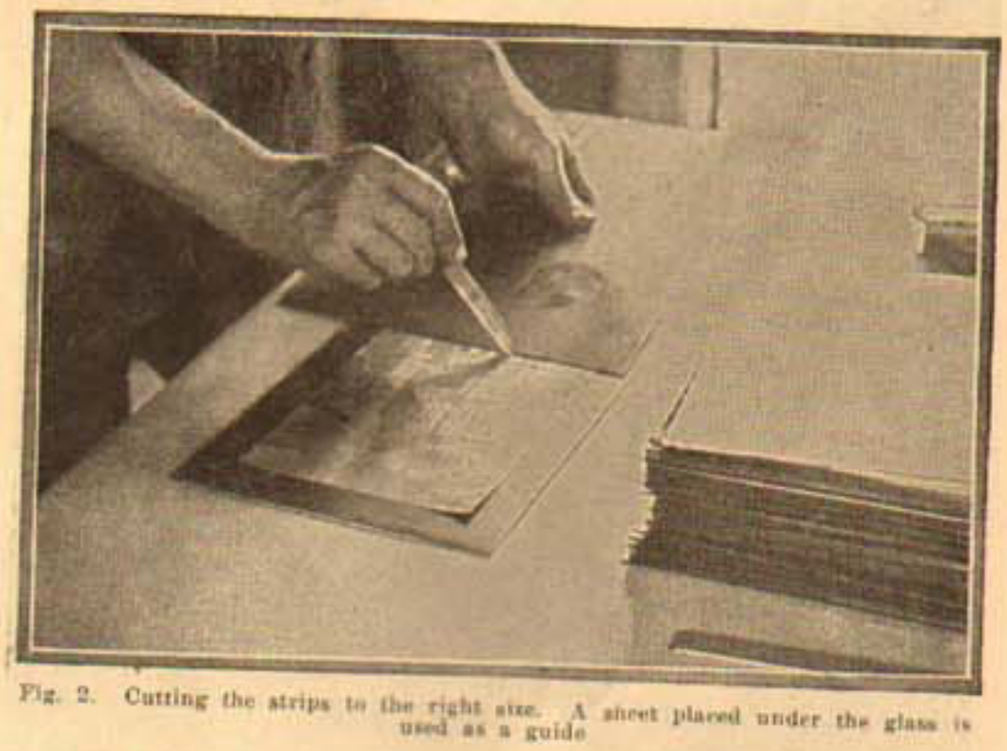


Fig. 2. Cutting the strips to the right size. A sheet placed under the glass is used as a guide

There is a knack in pasting condenser plates and also in laying the foil. One of our boys has worked out a little system that works well. He takes a batch of ten plates of glass (to make a .01 unit), and prepares all of his foil and lugs, and cleans the glass with a cloth slightly moistened in alcohol. The emulsion of the negative is left on the plate, as it does no harm and is troublesome to remove. He then starts coating one side of each plate with a thin, even coat of shellac until five plates have been coated: by the time the fifth plate is shellacked, the first one will be sufficiently "tacky" to take the foil. Fig. 3 shows how he lays this. A

spare glass is used in the right hand to hold the sheet of foil flat with the edge projecting a couple of inches. Upon the tacky shellac of the plate he then places the edge of the foil, gradually withdrawing the glass and sealing the foil with the fingers as he goes along. This method insures an accurately placed sheet of foil free from wrinkles. A final smoothing with the hand and the sheet is ready to be rolled or, as it is called by the photographer, "squeegeed." For this operation our worker places a sheet of paper over the foil to keep the surface of the roller clean and free from shellac.

Fig. 3. When the plate has been shellacked, the sheet is held over it on a dry plate and slipped off, smoothing with the fingers as we go along

This procedure is followed in the case of each succeeding plate until the five have been done on

one side. The next five are then pasted and coated with foil in the same manner. By this time the first five will have dried sufficiently for the worker to paste the reverse side of each, with the result that the work is continuous without any interruption for drying. When the ten plates have been pasted, they should be laid aside to dry over night before assembling.

In assembling the plates the worker will find that two plates of foil come together with a lug between them. This makes essentially one piece of foil electrically speaking. The object of coating both sides of the glass is solely to insure a perfect contact between the foil and the glass. Should any air spaces occur between glass and foil, a brush discharge takes place at that point. This gradually heats the glass, with the result that the uneven expansion causes a crack and an ultimate breakdown of the dielectric.

When the assembly is started, the worker should follow the instructions given to the letter, in order to insure correct connections, unless he is familiar with condenser construction. Let us paste a tinfoil lug on the left-hand end of a foil sheet on one plate. Next we place this plate upon the table with the lug *down* and projecting toward us and on the left-hand side. Upon the top tinfoil sheet of the plate, and on the right-hand side, we paste a second lug also projecting toward us. This gives us a lug from the bottom sheet on the left side and one from the top sheet on the right side. Next we place a second condenser plate on top of the first and paste a lug on the *left* side of its exposed tinfoil sheet. Our connections now embrace two lugs on the left and one on the right, but these three lugs give us a connection which places both condenser plates in multiple. The next plate is placed in position and a lug pasted to the right side of its exposed sheet of foil. This process is repeated until the ten plates are in position and a final lug is pasted upon the uppermost sheet of foil on the left-hand side. This gives us six lugs on the left and five on the right.

The unit thus formed is now to be stood on edge and the six lugs on the left folded together with a piece of flexible wire between them. A length of either friction tape or linotape is then used to bind both plates and the union of the lugs in a compact unit. The same treatment is accorded the lugs on the right side. This unit is then to be immersed in a tank of melted beeswax and rosin (equal parts) for an hour, after which it is removed and stood aside to drain and harden.

We now have a complete unit strong mechanically and electrically and impervious to moisture. This unit has a capacity of

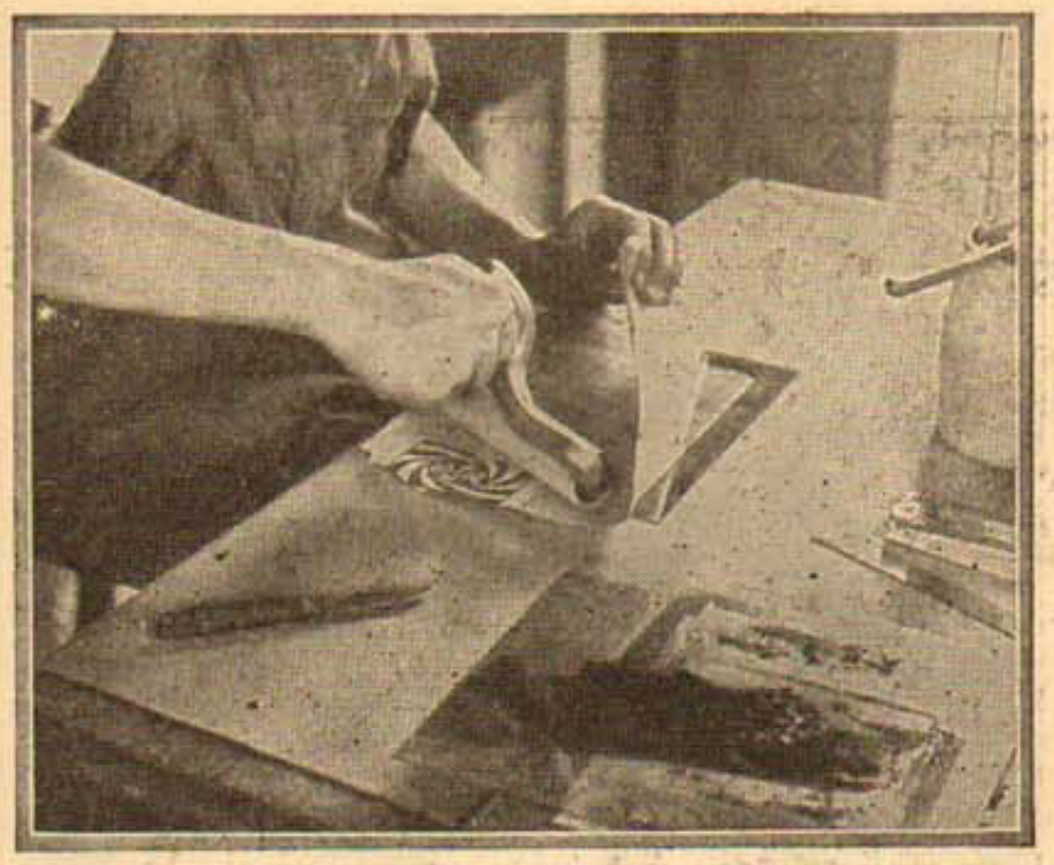


Fig. 4. Rolling the plate to insure perfect contact. Paper is used to keep shellac from the roller

.01 mfd., which is about the correct capacity for most standard ½-kilowatt wireless transformers adopted for 200-meter wavelength. If the set is to be used for any great length of time or if the condenser is to excite high frequency coils where the operation continues for hours, it is well to make up four of these units, placing two multiple sets of two each in series. This gives the same capacity, namely .01 mfd., but reduces the strain on each condenser to a quarter of that formerly imposed. We have used these single sections for hours at a time and have seldom had breakdowns, but we do not recommend such severe strain unless weight is an object and the operator can afford to carry an extra section or two in case one breaks down.

Fig. 6 shows how one manufacturer provides an admirable mounting for condensers of this type. The units are made up into sections of .01 mfd., but the ten plates in each unit are divided into two parts of five plates each and between the two sections a

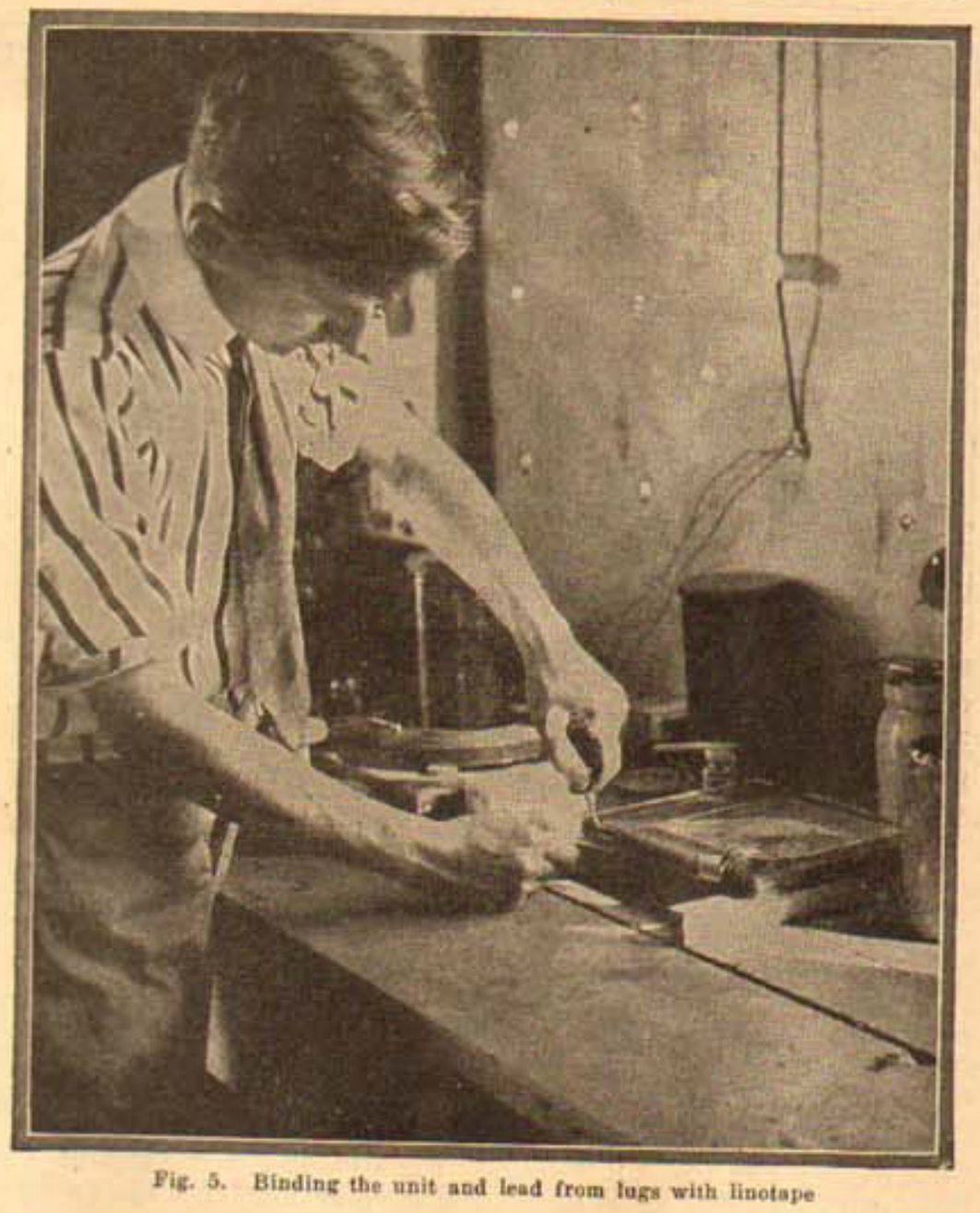


Fig. 5. Binding the unit and lead from lugs with linotape

sheet of ¼ in. thick wall board or whitewood is interposed. This partition projects all around and affords a mechanically good support for the unit.

Most good manufacturers specify the capacity required for use with their transformers. The average will be in the proximity of .01 mfd. For use with the

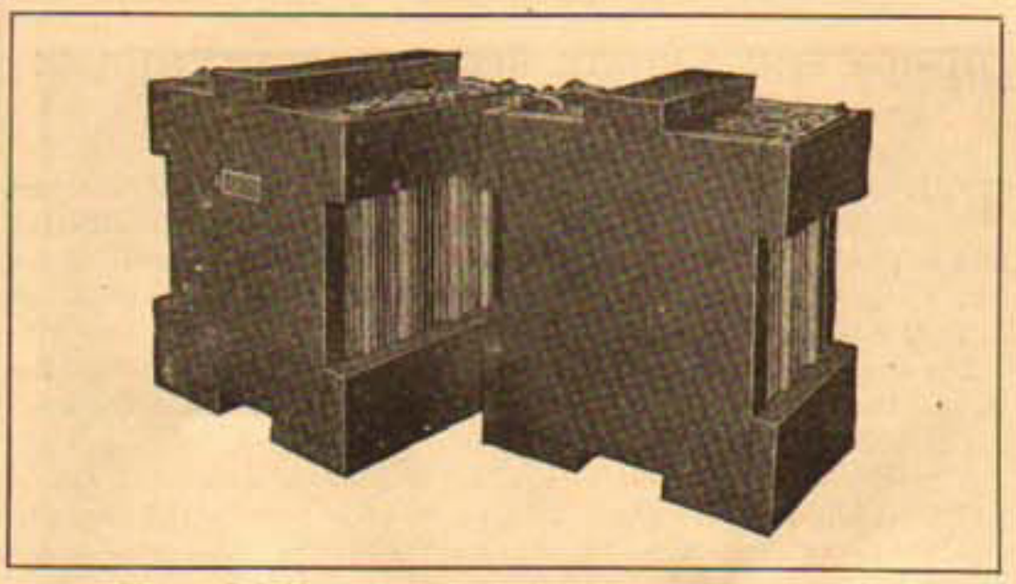


Fig. 6. Suitable cases may be constructed for a group of units

rotary gap, a somewhat smaller capacity will be found suitable.

Broadly speaking, the higher the voltage of the transformer the smaller the capacity need be in the condenser. For instance, in one well-known magnetic leakage transformer, the voltage a few years ago was something like 4000 and 6000 volts in the ¼- and ½-kilowatt transformers, respectively. Now, to conform with the law which prescribes a 200-meter wavelength as a maximum, the voltages have been increased to 9000 and 11000 volts respectively. Whereas, the old style transformer required a condenser of .03 mfd. to bring it to resonance, the new type requires a capacity of .01 mfd. In making up the condenser, therefore, it is well to ascertain the transformer voltage before starting work. The manufacturer is always glad to give this information.

For high frequency coils, the capacity may be varied to give different effects. Hence it is well to make up four or five sections in view of their cheapness, combining the units as occasion requires to perform various experiments.

Protector Cap for Chisel Handle

A chisel handle or screwdriver cap when subjected to the continuous blows from a mallet will soon show a tendency to split. To eliminate this, put a patent bottle cap over the end of the handle. Blows will give this cap a tendency to bind, thus preventing the handle from expanding and later cracking.

Contributed by Wm. Wernecke.